tion; (ii) that of an adiabatic universe in which there is no exchange of heat by radiation or contact.

Reverting to the formula: if the gravitation exerted on m increased by the fraction $1/k$ of itself for a rise of 1° C. in temperature, then at temperature 0° C. a change of gravitational energy into work would be accompanied, on Carnot's principle, by a gain of thermal energy equal to $273/k$ of its amount, which could scarcely escape notice unless k were large.

The sign in Dr. Todd's relation (1) seems to require change. An objection applies to his hypothesis (2) that it leads him to a temperature term in the law of force which has the same value at all distances.

Cambridge, March 4. J. L.

THE interesting letter from Dr. G. W. Todd in NATURE of March 1 opens new ground on the subject of gravitation and temperature. But does not the expression found need some modifications? Thus, in the general case with m at temperature θ and M at temperature Θ, we might write for the force the expression

$$F = G\frac{Mm}{r^2} + A\,(M \log \Theta + m \log \theta).$$

But even when thus generalised, the formula still seems unsatisfactory. Has Dr. Todd considered how to deal with the following curious facts?—(1) The temperature corrections vanish at *unit* temperature; (2) at the temperature of absolute zero the attractive force becomes *minus infinity, i.e.* an *infinite repulsion*! (3) the temperature correction is given as independent of r, the distance apart of the masses. Hence

$$\frac{\text{temperature correction to force}}{\text{force itself}} \propto r^2.$$

Thus, for large values of r, the temperature correction to the force might exceed the Newtonian value of the force itself. E. H. BARTON.

University College, Nottingham,
March 8.

Floating Earths.

WILL any of your readers kindly help in elucidating a passage of Strabo? It occurs in his Book XIII., i., 67. The Greek is fairly plain, so a translation will suffice:—

"It is said that at Pitane the bricks float on water, which has occurred also in the case of an islet in Tyrrhenia; for the earth is lighter than an equivalent bulk of water, so that it rides on the surface. Posidonius also says that he saw in Iberia a certain argillaceous earth, used for taking moulds of silver work, from which bricks were made which floated."

The site of Pitane is the modern Chandarli, or Sandarli, a small harbour on the west coast of Asia Minor, about 30 miles north of Smyrna and 15 miles south-west of Bergama (Pergamon). Tyrrhenia is, of course, Tuscany. Iberia is, no doubt, in this case Spain. The name is also used for a district in the Caucasus practically identical with the modern Georgia; but without qualification it should mean Spain; and Strabo elsewhere quotes Posidonius as an authority on natural phenomena in that country.

The two "earths" which occur to me as floating on water are pumice and meerschaum. Meerschaum is, of course, found in Asia Minor; Eski Shehr is the principal source. But that is a long way from the west coast, and I can find no record of its occurrence anywhere near Pitane. In any case, it does not seem likely that it should have been used for building purposes; and the use of the definite article, "the" bricks (τὰς πλίνθους), seems to imply that the substance in question was the ordinary building material of the district.

Pitane lay on the south side of the Kara-dagh, a large mass of eruptive rocks, andesite overlying tuffs, as I learn from Philippson, who has described the formation (*Reisen u. Forsch. im westl. Kleinasien*, Petermann's Mitth., suppl. 167 (1910), p. 95). It would seem, then, that in the case of Pitane the material must have been tuff. Is it possible that a tuff porous enough to float on water could be used as a building material, or that passably durable "bricks" could be made of it?

The floating "islet" in Tuscany may, I suppose, have been a mass of pumice from the Lipari Islands drifting northwards. Such islets are recorded to have floated about the Ægean Sea after the great eruption of Santorin in 1650, and even to have blocked some of the ports. But though the Lipari Islands contain enormous masses of pumice light enough to float, I can find no record of any having been actually ejected into the sea in historical times. Can anyone tell me if there is such a record?

The "argillaceous earth" in Spain clearly cannot have been tuff or pumice. Can it have been meerschaum? This material is, of course, capable of delicate carving; would it be suitable for making moulds for copying silver work? It is said that there are limited deposits of it in Spain. It may be noticed that the quotation from Posidonius does not imply that it was actually used for building, but says only that bricks "formed" (πηγνυμένας) from it will float. This may mean no more than that blocks of the shape and size of a brick will float. I am not clear as to the exact meaning of πηγνυμένας—whether it implies any process more than mere cutting. One would naturally expect it to mean "congealed" or "solidified." Meerschaum is, I understand, soft when dug, but hardens on exposure to the air. Perhaps, therefore, the word may mean "hardened." On the other hand, I feel confident that in the phrase ᾗ τὰ ἀργυρώματα ἐκμάττεται the verb is used in the technical sense of taking a mould or impression, not, as some have thought, with the trivial meaning, "with which silver work is cleaned."

Anyone who can enlighten an ignorant Hellenist on these points would be assured of his gratitude.

WALTER LEAF.

6 Sussex Place, Regent's Park, N.W., February 24.

SCIENTIFIC ASPECTS OF FUEL ECONOMY.[1]

THE appointment of a Board of Fuel Research by the Committee of the Privy Council for Scientific and Industrial Research on the recommendation of the Advisory Council was noted in NATURE of February 22, and something may perhaps be said with advantage on the real and pressing need for securing, so far as it may be done by official efforts, the fullest investigation of the potentialities of fuel.

To those occupied with the study of the scientific utilisation of coal, the crude and wasteful way in which we, as a nation, have been maltreating our supplies of that irreplaceable raw material has been for some time past a depressing spectacle. Recognition of the value of purely thermal economies has been fairly general, although the quantities of fuel used in feeding small steam-engines permit no unqualified statement to that effect; but the less instinctive appreciation of the chemical value latent in coal has been a slow, and is still a stunted, growth. Our recent needs for benzene, toluene, and phenol for the making of high explosives, and the publicity given to the coal-tar dye question, have opened many eyes to the value of carbonisation, apart from its production of coke for our blast furnaces and gas for our towns; but even now the iniquity of the prevalent nitrogen waste passes almost unnoticed. To regard coal always as a source of available heat, tar, and nitrogen is a habit of mind to cultivate; consistent condemnation and eventual elimination of methods of use which offer violent offence to that regard will follow.

---

[1] Report of the British Association Committee on Fuel Economy, September, 1916.
Memorandum by Chief Engineer, the Manchester Steam Users' Association, for the year 1915.

The particular directions which reform will take, or ought to take, in the many uses to which coal is put are less obvious than the urgent necessity for reform. Carbonisation, with all its possible variation of methods and results, demands a closer systematic study on the small and large scale, in laboratories suitably equipped and staffed and in the works. Comparison of the results obtained by Wheeler at home and by Pictet abroad with those of ordinary coke-oven or gasworks practice shows the extent to which the nature and quantity of products are dominated by variation in conditions of operation, and emphasises the necessity for a thorough knowledge of the processes involved in the transition from primary to secondary products of carbonisation, with a view to their intelligent control.

The work of Bergius, although of uncertain value on the industrial scale, touches upon another possibility, that of carbonising under very high pressure; if successful, it would demand a new type of plant, somewhat analogous to that employed for the Haber synthetic-ammonia process, and presenting new problems of construction and working. At the other end of the scale stands carbonisation with reduced pressure, already under trial on a scale above that of the laboratory. Less removed from current practice in carbonisation are the low-temperature processes, such as the Del Monte, and the presumably improved form or development of the ill-fated Coalite process, which, it is hoped, will receive an adequate trial at Barugh. Several questions await an answer from such processes. It is conceded that they can produce tar rich in low-boiling-point constituents, but are these constituents to be mainly paraffinoid, as certainly seems probable, or aromatic, with benzene and toluene? The ammonia yield is in question; laboratory experiments indicate that a real beginning is not made in forming ammonia from coal by heating until a temperature of 500° C. is exceeded, and that 700° to 800° C. is necessary for a yield which the standard carbonising practice would call good. Soft coke has undoubted advantages for the open grate, but can it be made for carrying in bulk without crushing? These are some of the simpler issues.

As regards nitrogen, the Mond process, with its 60 to 70 per cent. recovery as ammonia, is satisfactory, but the gasification of coal in an air-steam blast gives of necessity a gas too highly diluted with nitrogen to be of any service for high-temperature operations, excepting in large furnaces where regeneration can be employed. The tar, too, has its peculiarities. Otherwise the process is successful in practice, as it is sound in principle, and all concerned with its initiation are to be doubly congratulated, in the first place on an extremely valuable contribution to the science and practice of fuel utilisation and in the second on the comparatively advanced stage to which the working-out of the process had been carried before it was declared ready for use.

None of our methods of using fuel can be regarded as attaining the ideal, but the most disturbing factor in the situation is that such advances as we have made are not properly utilised; even to-day the great bulk of our domestic heating is done with raw coal in the open fire, and our great modern power-houses are mainly run with raw coal in their boiler furnaces. The pall of smoke over our cities signalises the daily sacrifice. Then, again, our metallurgical industries, although using gaseous fuel largely in regenerative open-hearth furnaces which do secure thermal economy, still neglect and destroy the chemical value of coal by gasifying without recovery of either tar or ammonia.

The country was never so ready as now to accept the application of a remedy for these evils, but must first feel that before it lies a rational treatment, based on a sane and sober diagnosis, and not on the facile verbalism of ill-considered propaganda. Some few simple prohibitions, automatically progressive in their application, may be found advisable, and, if so reasonable as to be practicable, would probably be effective in checking criminal waste, and at the same time encourage those developments in the technique of fuel utilisation on which we must depend ultimately for success.

There has been wanting sufficient systematic attention to fuel problems from investigators, administrators, and legislators alike. It is true that, owing largely to the initiative and foresight of Prof. Smithells, the University of Leeds (followed more recently by the Imperial College in London) has established a department of fuel technology, and that the gas industry has generously endowed there the Livesey chair in memory of a great leader; but how long has the paramount necessity for what were pioneering ventures a few years ago been recognised, and how very much more remains to be done before it can be claimed that the subject of the scientific utilisation of fuel is receiving anything like adequate study or the same degree of public support as is accorded in America and Germany. Committees are to the fore just now, and the British Association has appointed one, with Prof. Bone as chairman, for the investigation of fuel economy, the utilisation of coal, and smoke prevention; this may be one sign of an awakening. The terms of reference are wide, which consideration presumably justifies a list of members somewhat disconcerting in its length.

The committee has issued a first report, and if it relates intention rather than achievement, that is only natural at a time when so many of the committee must be very fully occupied with urgent national duties. The field has been mapped out, however, and a number of sub-committees appointed to give special attention to sectional work.

> Having regard (says the report) to the magnitude of its work, and the fact that the coal question is one upon which almost every branch of manufacturing and transport industry is dependent, the original committee of thirteen members appointed by the Association in October, 1915, decided to exercise somewhat freely its power of co-option so as to make a general committee sufficiently large and representative of all the important interests involved.

The chemical and statistical sub-committee, with Dr. J. T. Dunn as chairman, is proposing to occupy itself with the chemical investigation of coal, the survey of the chemical character of the principal British coal seams, and an inquiry into the amount of wastage due to coal which for one reason or another is at present left behind in the pits. Another sub-committee, with Mr. T. Y. Greener as chairman, is to deal entirely with carbonisation. A return is to be prepared which, when completed,

> will enable the committee to arrive at an approximate estimate of the margins of possible economies in the shape of improved utilisation of the coal carbonised, which can now be effected in the coking industry, and the directions in which further progress is likely to be made. A memorandum is also in course of preparation describing the more important developments of the by-product coking industry, from its inception until the present day.

"The committee would welcome the offer of proper facilities to enable them to investigate the question of low-temperature carbonisation."

Dr. J. E. Stead is chairman of the sub-committee for metallurgical, ceramic, and refractory materials, which is concerning itself mainly with ascertaining actual fuel consumptions in these industries, and

> will endeavour to draw up a statement as to the best lay-out and arrangement of a combined by-product coking, iron-smelting, and steel-making plant, from the point of view of utilising as completely as possible surplus gases and waste heat, and thus realising the maximum fuel economy in the heavy steel industry.

A sub-committee on power and steam-raising, with Mr. C. H. Merz as chairman, is to investigate the economies in fuel which would result from the use of improved methods. Regarding the practice of to-day,

> in view of the impossibility of obtaining accurate returns of fuel consumption per horse-power-hour from the whole of the power users in this country, it has been decided to investigate the matter by asking for detailed returns from typical factories in various trades and in different districts throughout the country, selected by members of the sub-committee who have special knowledge of particular trades. Special memoranda are in course of preparation on questions of organisation of power production for industrial and transport purposes, the use of large turbine- and gas-engines, and other important aspects of the power question.

Mr. E. D. Simon, secretary of the committee, is also acting as chairman of the domestic fuel sub-committee, which feels

> that it will be wise to recognise at the outset that there is probably no single solution of the domestic heating problem which is likely to be universally adopted within any measurable period of time; and that, therefore, it should preferably concentrate its efforts upon questions of more immediate practical importance.

It proposes, therefore, to examine the possibilities of existing systems and methods, and also the relative efficiencies of coal-fired, gas-fired, and electrical heaters.

> Arising out of the present extensive use of solid fuel in domestic fires, the sub-committee will also consider the important question of the prospects of substituting for raw coal some form of carbonised fuel (semi-coke or coke). There can be no doubt but that if such a substitution could be effected, without either increasing the domestic coal bill or involving some other disadvantage, not only would there be a great addition to the amount of valuable by-products annually obtained from coal consumed in the Kingdom, but also the smoke nuisance in our large centres of population would be materially reduced.

The scheme of work which the committee and its five sub-committees set out is frankly ambitious and highly comprehensive, and although this first report would be more accurately described as a prospectus, that peculiarity will presumably not attach to future issues.

A memorandum on a special aspect of the fuel question has been issued to the executive committee of the Manchester Steam Users' Association by Mr. C. E. Stromeyer, their chief engineer; it is concerned primarily with steam-raising. The author thinks that "our manufacturers have been spoiled by the ease with which they could obtain the very best coal in the world," and deplores "our almost universal practice of over-working boilers." On the Continent, he points out, first-class coal cannot be obtained, "but there the works provide themselves with ample boiler power, and, on the whole, they obtain a higher efficiency than we can hope for with our superior coal but hard-worked boilers." To use coke and conserve by-products would necessitate the same reform. "Steam users naturally do not like coke, partly on account of its relatively high price, and partly because it would require larger boilers than the present ones in which to burn it with as good effect as the best coal." But Mr. Stromeyer does not expect too much from this source; he considers a number of working results with steam-engines of various types, and concludes:—

> The fuel economy question may therefore be briefly summarised by saying that hardly any improvement is likely to be effected in the economic working of boilers, for, as is well known, there is only a margin of about 20 to 25 per cent. to play with. Considerable pecuniary saving might often be effected by increasing the number of boilers, so as to be able to burn a poor and relatively cheap fuel if this can be got. Our chief hopes will therefore have to be centred on engine im-

provements, for here large savings might be possible, because at present about eight units are thrown away for every one doing useful work.

The steam turbine is regarded as combining the greatest number of advantages among the prime movers of to-day, and as an interesting novelty the Lundholm turbine is mentioned, consisting of two discs and blades revolving in opposite directions.

> As there is no difference of expansion of the two discs there is every prospect that the clearances of the blades can now be reduced to a minimum, and that this very serious source of loss will be materially reduced.

The possibilities of the gas-engine, and particularly of the internal-combustion turbine, perhaps in the near future, appeal to Mr. Stromeyer and lead to the following:—

> From a national economic point of view the combination of the internal-combustion engine with electric distribution of power would seem an ideal one. Our collieries would then be encouraged to mine even our dirtiest coal. This coal would produce by-products for farmers and for the coal-tar industries and supply the engines with suitable gas, and our factories would receive their power at a lower cost than they could produce it.

The general attitude of the author seems to be that of an experienced engineer, convinced that economy in power production is going to be so vital to us after the war that strenuous effort and a bold and encouraging policy as regards both invention and research are primary conditions of our continued commercial progress.

Although in all probability no such effective blight could be laid upon the work of scientific investigation in any field as that of undue centralisation and impossible regimenting, enough has perhaps been said to indicate that the scale of research necessary for adequacy in the domain of fuel necessitates, among other things, liberal financial support, and if the Government is going to provide that support it will naturally seek for guidance. Presumably the new Board of Fuel Research is to guide. Its director is Sir George Beilby, whose varied industrial and scientific experience should prove of the greatest value. Sir Charles Parsons, Mr. Richard Threlfall, and Sir Richard Redmayne will assist him as members of the board, and Prof. W. A. Bone will act as consultant. This form of organisation for research is new to the country and its working will be watched with great interest. There are pitfalls in the way, which it may be difficult to avoid, and would certainly be folly to ignore, but an administration directed with liberality of spirit to really national ends will go a long way to command success.

John W. Cobb.

THE SEPTIC PROBLEM IN WAR.

Of all the many varieties of wounds with which surgery has to deal, incised, contused, lacerated, etc., the most dreaded one is the punctured variety. This is because the inflicting weapon is almost necessarily infected with pathogenic organisms, and because these organisms are therefore implanted in the depths of a long and narrow track, into which antiseptics can be made to penetrate only with considerable difficulty.

Of all punctured wounds those produced by gunshots are the most difficult to deal with. The reasons for this become obvious upon consideration. The mere force of impact, in the first place, is an unusual and important feature. The energy in foot-tons of a projectile of known weight and velocity can easily be calculated, and it is to be remembered that this energy is concentrated upon a small area, with the result that the actual track of such a missile in human tissues is a tunnel the walls of which are *dead tissues*.

The importance of this fact in favouring bacterial growth is immense. Moreover, the tunnel is surrounded by a cylinder of tissue of which the constituent elements are bruised and under the influence of local shock, so that their vitality and resisting power to bacterial invasion are reduced. If such a missile strikes hard bone, a high degree of shattering and splintering takes place, while portions of broken bone are driven into the surrounding muscles, sometimes lacerating important vessels and nerves, and even bursting through the skin, and forming a large opening known as an "explosive exit." Owing to the ballistic properties of the pointed bullet, which is now used by all countries, and which tends to turn over on its short axis on impact, the proportion of these severe wounds is somewhat greater than in previous campaigns.

Another difficulty in the case of gunshot injuries is their special liability to severe forms of septic infection in the circumstances of the present campaign. In South Africa military surgeons found that a large number of wounds, even when bone was involved, showed small wounds of entrance and exit, and, so far as infection was concerned, merely required cleaning and sealing to heal without trouble. This was in part due to the shape of the bullet and its tendency to traverse the tissues by a straight course without turning on its short axis. This meant small external openings, and therefore less liability to infection from them. But the chief cause of the immunity from infection was the comparative dryness of the country, and a soil for the most part uncontaminated by human occupation or cultivation.

The conditions in the European area of the present conflict are very different. The humidity of the climate is greatly in excess of that of South Africa, and intensive cultivation means copious manuring of the soil, so that most of the ground occupied by our troops is thoroughly sown with bacteria of fæcal origin, which include, besides those ordinarily called pyogenic or pus-producing, the special germs of tetanus, malignant œdema, and gas gangrene. It is in ground thus infected that our soldiers sleep, take their food, and are occasionally buried alive. Their skin and clothes are plentifully smeared with bacterial mud, and it is no matter for surprise that when a bullet passes into their bodies